HAWAII AGRICULTURAL EXPERIMENT STATION
E. V. WILCOX, Special Agent in Charge

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INSECTS OF COTTON IN HAWAII

BY

DAVID T. FULLAWAY,
ENTOMOLOGIST

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CONTENTS.

REPORT ON THE INSECTS WHICH AFFECT THE COTTON PLANT IN THE HAWAIIAN ISLANDS

By DAVID T. FULLAWAY, Entomologist.

INTRODUCTION.

The present interest in the possibilities of cotton-growing in these islands required that some attention be given to the insects which affect the cotton plant, for whether the crop can be grown profitably or not will depend in large measure on the extent to which the yield is diminished or damaged by insect attacks. Although it has been more than seventy years since the first cotton was planted in the islands, its growing up to the present time has not been one of the agricultural industries, and one attempt at least to make it so was without success. For the past two or three years, however, three varieties of cotton, Sea Island, Caravonica, and Chinese, have been grown experimentally on the grounds of this station with remarkably promising results. While the damage to the yield by insects was by no means inconsiderable, it was easily demonstrated that cotton of a fine grade and large yield could be grown under favorable conditions.

The writer desires to acknowledge the assistance received in the preparation of this bulletin from co-workers in Honolulu and elsewhere, to whom he expresses his warm thanks.

The insects are treated in the order in which they attack the plant.

STEM MAGGOT.

Cotton recently planted in Honolulu was noticed soon after germination to be affected by a stem maggot. Only a small proportion of the plants were attacked, but in each case the plant was killed, making replanting necessary. The maggot was found within the stem and above the point of attack the circulation was completely stopped. As a result of such injury the plant wilts and ultimately dies. Below the point where the maggot was working the stem was abnormally swollen. Up to the present time attempts to breed the fly from the maggot have not been successful. It is, however, likely to be a common species, as carnations and pigeon-peas have been noticed to suffer similar attacks.

WIREWORMS.

Wireworms (the larvae of Elaterid beetles) are unfailingly present in the soil here, in which they feed naturally on the roots of weeds and decaying vegetable matter. From these they readily turn to cultivated plants, especially tender seedlings. They are easily distinguished by their elongate, wire-like form, their shiny yellow or brown color, and their hard, inflexible integument. The one attacking germinating cotton is probably the larva of *Simodactylus cinnamomeus* Boisd., although other species may be implicated.

FIG. 1–Wireworm, enl. (Original.)

Wireworms attack the cotton usually just beneath the surface of the ground. The injury is not strikingly apparent except in its results—the withering of the plant—but close observation will disclose that the parenchyma is destroyed for the space of an inch or two, which turns brown. Wire-worm attacks, in some instances, have been quite severe, as large a proportion as one-third of the plants in a field being destroyed. The necessitated replanting constitutes a serious setback to the crop.

CUTWORMS.

Of the several insects injuring the cotton plant in the early stages of its growth, cutworms undoubtedly do the greatest damage. From the time the seedling gets above the surface of the ground until it is a foot or more in height and has begun to square out, it is subject to the attacks of these extremely voracious and ubiquitous larvae. The cutworm that has been observed to attack cotton most frequently is the larva of the common moth, *Agrotis ypsilon* Rottenburg, although the larvae

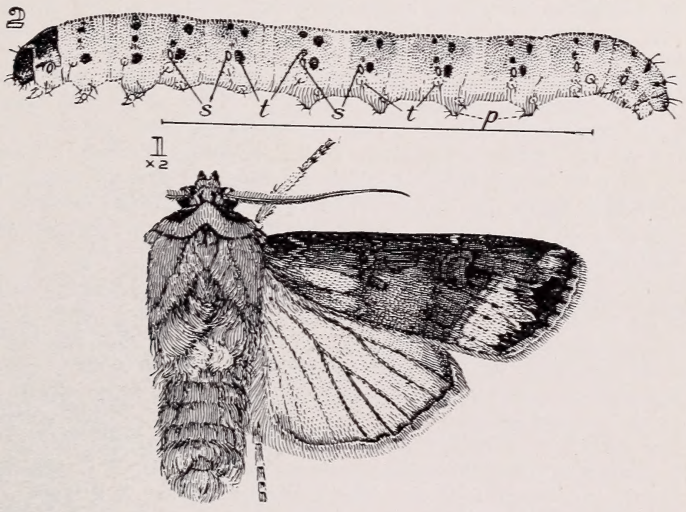

Fig. 2—Cutworm and moth, *Agrotis ypsilon* Rott. Both twice nat. size. (Copied from Swezey.)

of *Heliophila unipuncta, Agrotis saucia, A. dislocata* and *A. crinigera* have similar habits and may also attack cotton. Mr. O. H. Swezey,[a] assistant entomologist of the Hawaiian Sugar Planters' Experiment Station, gives the following account of the life-history of *Agrotis ypsilon:*

"The eggs are domeshaped, about 0.5 mm. in diameter, and creamy white in color. There is a small circular depression at the upper pole

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a Hawaiian Sugar Planters' Expt. Sta., Div. Ent. Cir. 5.

from which radiate numerous ridges running down the sides to the base or surface in contact with a leaf. The eggs are laid on the surface of leaves or stems of plants near to the ground. From one to many eggs may be placed close together in one batch, and one moth may produce several batches amounting to two or four hundred eggs.

"The larvae hatch from the eggs in a few days (usually two to four). They molt five times at intervals of two to six days and become full-grown in about one month. The full-grown caterpillar is about 1.75 inches long (45 mm.). It is of a nearly uniform dark, greasy-gray color, paler below. The spiracles are black. The tubercles are conspicuous, showing as regular rows of brownish dots. Head and dorsal part of segment behind head dark brown.

"The pupa is formed in an earthen cell a little below the surface of the soil. It is about .75 inch long (20 to 23 mm.), uniform medium brown in color, with a dark dorsal band at apex of abdominal segments 4, 5, 6 and 7, containing irregularly arranged small pits. At the tip of abdomen are two large tapering spines, black at base and pale at tip, a little distance apart at base, slightly diverging but curved together at their tips.

"The moth emerges from the pupa in ten days to three weeks. It is about two inches in expanse of wings. It is of a dark gray color with black eyes and collar. The fore wings are velvety blackish brown except the outer one-third, which is paler brown. There is a distinct U-shaped black mark a little beyond middle of wing, a black dash extending from its outer side, and two black dashes farther toward the end of the wings. Hind wings light gray, brown on outer margin and on veins."

He says of it:

"It is a well-known garden cut-worm throughout the United States. It ranges in America from Hudson Bay south to Uruguay, is common in Europe, also occurs in northern and southern Africa, India, China, Japan, Java, Australia and New Zealand. It is a typical cutworm in its feeding habits, i.e. feeding on plants at night-time, often cutting off small plants at or below the surface of the soil, and hiding under leaves, trash, or burrowing in the soil during the daytime. It is a very general feeder, attacking nearly all kinds of garden and field crops and even weeds. * * * In the United States they are particularly troublesome to corn, cotton, cabbage, tomato, and tobacco, attacking the young plants, one cutworm often destroying several plants in one night. In India they are destructive to young tea and coffee plants and opium."

As Mr. Swezey observes, the cutworms are night-feeders. Their method of attack is to eat directly through the stem, cutting it off just above the level of the ground. They are usually present in large numbers and inflict incalculable damage. If, as is often the case, half of the plants in a field are attacked and replanting becomes necessary, with the consequent setback to the crop, cutworm injury becomes a serious matter indeed. Replanting to such an extent may be avoided

by planting several seeds in a hill, in the hope that some of the plants may escape attack, but even this measure might be ineffective in a badly infested field.

Remedies: Perhaps the best remedy for cutworms and wireworms is found in the use of poisoned baits. These are prepared by combining a poison—such as arsenic—with some food substance for which the cutworm has a decided taste. White arsenic is most generally used, either on freshly cut alfalfa, or combined with molasses, cane sirup or honey and mixed into bran, middlings or flour. Use one pound of arsenic to ten of bran. Fifty to seventy-five pounds should be sufficient for one acre.

Cutworms are kept in check to some extent by dipterous and hymenopterous parasites as well as by birds.

APHIDS.

Cotton suffers more or less from aphids all the time, and at certain times or seasons the damage by these insects becomes a great handicap to the plant. On germinating seedlings aphid attack is serious and threatening, often demanding active measures to save the plants. Specimens of the aphid on cotton recently submitted to the Bureau of Entomology, United States Department of Agriculture, were determined by Mr. T. Pergande to be the well-known species, *Aphis gossypii* Glover. This species is a common pest of cotton in the United States, but there it is heavily parasitized and consequently, as a pest, of little importance. In these islands, as far as is known, it is unparasitized, although fairly well kept in check by Coccinellids and other predaceous species.

Aphid injury is at a minimum during the hot, dry months of April, May, June, July, August, September, and October. With the oncoming of the cold and wet weather in the latter part of November and through December, indeed through the remaining months—January, February, and March—aphids are likely to do considerable damage to cotton, although any abnormal increase is soon brought in check by ladybirds.

Remedies: When germinating plants are threatened by aphid attack, the liberal use of tobacco dust is considered advisable. Tobacco dust is a cheap insecticide and is easily applied. Mature plants should be sprayed with kerosene emulsion.

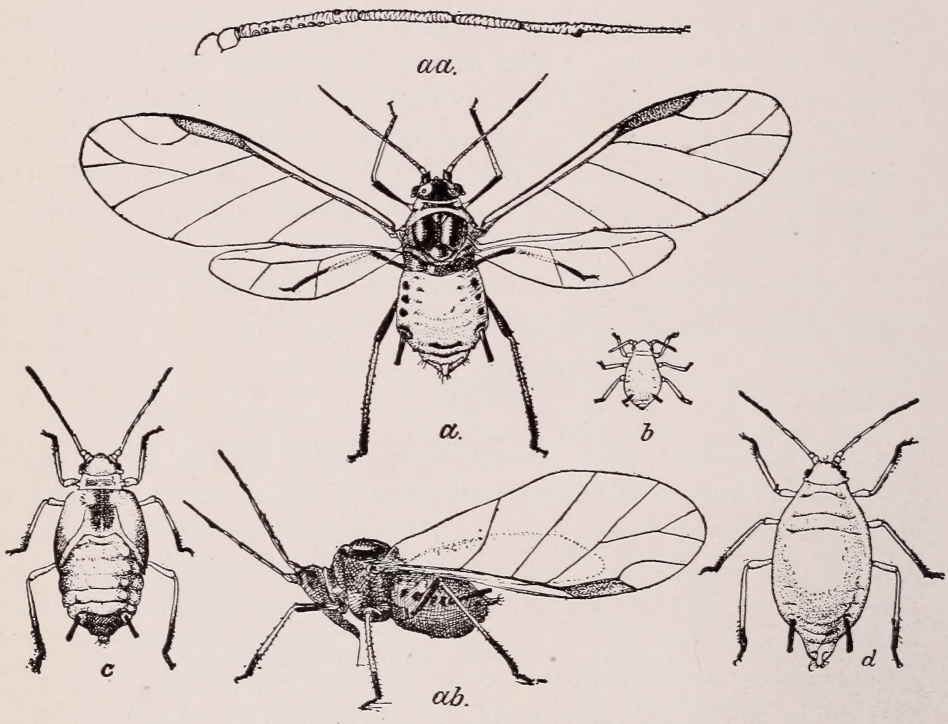

FIG. 3—Cotton aphis, *Aphis gossypii* Glov. *a*, winged female; *aa*, enlarged antenna of same *ab*, dark female, side view, sucking juice from surface of leaf; *b*, young nymph or larva; *c*, last stage of nymph; *d*, wingless female. All greatly enlarged. (Copied from Chittenden.)

The introduction of the common parasites of the cotton aphid from the United States seems entirely feasible, and could only bring the most beneficial results.*

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* An effort is being made by this Station to secure aphid parasites through the cooperation of the Bureau of Entomology, U. S. Department of Agriculture.

JAPANESE BEETLE.

The so-called Japanese beetle, *Adoretus tenuimaculatus* Waterhouse, has injured cotton to some extent, attacking the foliage. It has not been considered as serious a pest with regard to cotton as it has with other cultivated plants, although a small planting of Chinese cotton was utterly defoliated by it. This variety seems to be especially susceptible, while the Caravonica cotton shows little susceptibility to attack.

FIG. 4.—Japanese beetle, *Adoretus tenuimaculatus* Waterhouse. Natural size indicated by line. (Copied from Kotinsky.)

MEALY BUG AND SCALE INSECTS.

Two serious pests of cotton are found in the mealy bugs (Coccidae) known scientifically as *Pseudococcus virgatus* (Ckll.) and *Pseudococcus filamentosus* (Ckll.). Neither of them is confined wholly to cotton, each having a long list of hosts among both wild and cultivated plants. For this reason their attacks are likely to be more or less intermittent and perhaps negligible. An outbreak of either in the cotton field, however, would result in considerable damage to the crop and would be most difficult to control by artificial means.

FIG. 5.—*Pseudococcus virgatus* (Ckll.) Adult female. (Photograph by author.)

Pseudococcus virgatus is a common pest of cultivated plants in several countries. Cockerell discovered it in Jamaica on cultivated violets, algaroba, and other wild plants; Koebele

found it in Mexico (at Cuautla in Morelos) on coffee; and it is also reported to occur in Mauritius. In addition to the host plants already mentioned, cactus, cocoanut palm, *Acalypha* and *Tribulus cistoides* are given. In these islands it has been found on *Dolichos lablab*, poinsettia, oleander, violets, litchi, and klu as well as on cotton. The species is recognized by its elongated shape and the peculiar character of its white waxy secretion, which appears flake-like and glassy. The secretion of immature specimens takes the form of long slender glassy threads, which project from head, back and sides in all directions, forming a sort of web. There are, besides, two long white waxy caudal filaments but no apparent lateral filaments except the fine filamentous threads already referred to.

Life history. The eggs are minute, oval, and golden yellow. A single female will deposit apparently several hundred or more. The eggs hatch within a day or two. There are two larval stages characterized by six and seven jointed antennae respectively. The first larva measures 0.3-1 mm. The second larva 1.5-1.8 mm. The adult female has 8 jointed antennae and is 2 mm. in length. The first larval stage occupies twenty days, the second larval stage eight days, the latter giving place to the adult female. Coincident with the appearance of the adult female occur the male pupae, and six days later the male itself emerges. Copulation takes place at once. The male, as is usual in the Coccidae, is much inferior in size to the female. It has two chalky-white, iridescent wings, long caudal filaments, and antennae with ten joints. After fecundating the female the male soon perishes. The female survives until its eggs are formed and deposited, which may require weeks. While the eggs are forming its body becomes tumid and vastly increased in size. The life-cycle may be said to cover at least two months. Apparently the species breeds uninterruptedly throughout the year. With its great fecundity and rapid growth, its ability to increase in enormous numbers and become a pest is not at all surprising. It is, however, undoubtedly held in check by climatic conditions as well as by natural

enemies, chief among which are the many introduced species of Coccinellidae (ladybirds).

The following technical description is inserted to facilitate the determination of this species by entomologists, or anyone who may have access to a compound microscope:

"Female—4½ mm. long. Very white, mealy brown above except dark purplish gray subdorsal stripes which are broadly interrupted centrally. Caudal filaments about 2 mm. long, i.e. about half length of body. No obvious lateral appendages. Segmentation distinct. Beneath whitish, legs pale brown. The caudal filaments are rather slender but not filiform like those of *D. longifilis*. The lateral appendages seem to be represented by long and very fine hairs, which are obvious in the young but are lost in the adult. Very young individuals are pale yellow. Femur (of adult) about as long as tibia; tibia about three times as long as tarsus. Antennae with eight joints—3 and 8 subequal, or 8 a *little* longer; 2 sensibly shorter than 3; 4 rather longer than 5; 5, 6 and 7 about equal.

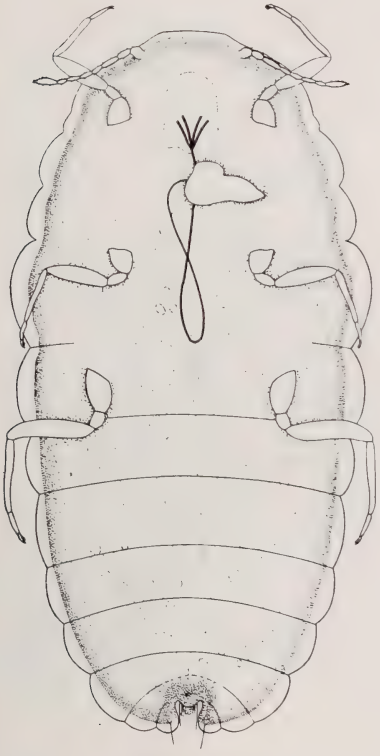

FIG. 6.—*Pseudococcus virgatus* (Ckll.) Adult female. (Original)

"Male brown. Antennae brown; all the joints with long hairs—3 longest, longer than 1 and 2, decidedly longer than last; 4 same length as 6; 5 a very little shorter than 4; 7 decidedly shorter than 6 and slightly shorter than 5; 8 same length as 7; 9 still shorter but not quite so short as 1; 10 same length as 5. The second joint, which is about as long as 7 or 8, is conspicuously enlarged, much thicker than the joints following."

Pseudococcus filamentosus, perhaps the most destructive species of Coccidae in these islands, has been a pest of cotton for several years. It also attacks other plants—hibiscus, mulberry, grape, but chiefly citrus trees. According to Koebele, it was introduced about 1891, from Japan. It also occurs in Jamaica and Mauritius. It attacked citrus trees at first but

soon spread to all kinds of ornamental plants. Residents of Honolulu of fifteen years ago state that hundreds of trees were destroyed by it and that the trees were white with the insects as if covered with snow. About 1894 the Coccinellid beetle, *Cryptolaemus montrouzieri* Muls., was introduced by Mr. Koebele from Australia especially to prey on this pest. The ladybird became established and increased steadily. Since that time the

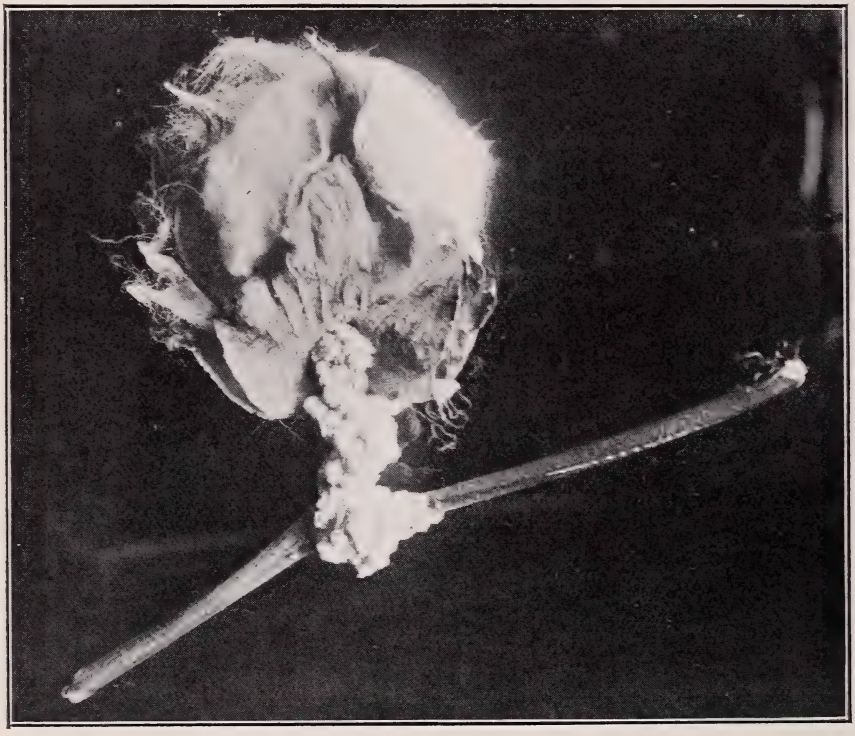

FIG. 7.—*Pseudococcus filamentosus* (Ckll.), showing globular egg-sacs clustered on cotton stem. (Photograph by author.)

ravages of *Pseudococcus filamentosus* have been greatly reduced, although occasionally the balance of nature is disturbed and *filamentosus* becomes injurious.

The species is readily recognized by the large clusters of yellow-tinged, globular egg-sacs which it forms on the stems and bolls of cotton.

Life history. The egg-sac contains several hundred eggs.

The eggs hatch in about fifteen days. The larva when hatched is naked but is soon covered by a white waxy secretion which becomes heavier as the insect increases in size. The larva is about one-ninetieth of an inch in length and is characterized by the possession of six-jointed antennae. The larva molts after 20 days, giving place to the adult, which is characterized by seven-jointed antennae. Immediately after the molt the insect is quite small; growth is very gradual and it takes several months for it to attain its full size and form the egg-sac. The male has not been observed.

The following technical description is inserted to facilitate the determination of the species by entomologists:

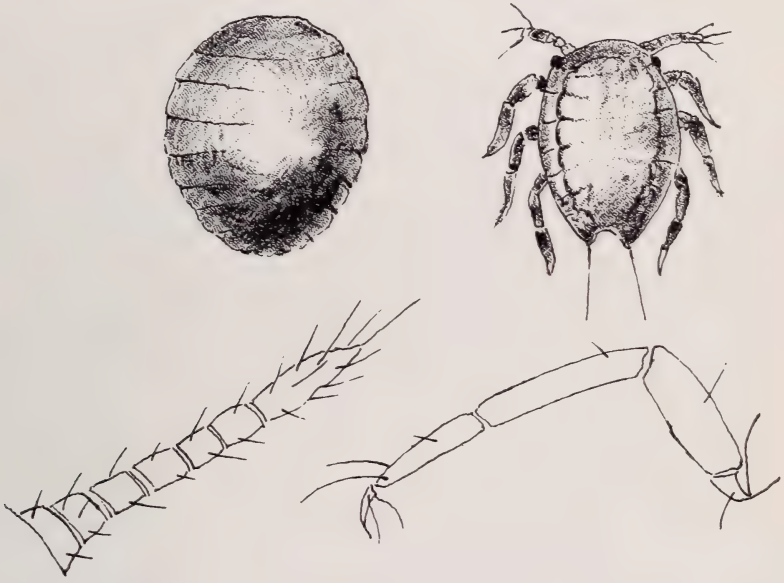

FIG. 8.—*Pseudococcus filamentosus* (Ckll.) Adult female; antenna; leg; larva. (Copied from Maskell.)

"Female insect covered by globular sacs of whitish or yellow cotton, which are frequently aggregated in large masses on the twigs. Diameter of sac about one-eighth inch. Sac of male pupa not observed. Adult female dark red or purple, slightly elliptical or subglobular. Length about one-twelfth inch. Segments inconspicuous. Antennae of seven joints, of which the seventh is the longest and largest and the fifth the smallest. The rest subequal, all the joints bearing a few hairs, which are most numerous at the extreme tip. Feet moderately strong. Tibia about one-third longer than the tarsus. There is not

any long hair on the trochanter nor any terminal spine on the tibia. The tarsal and claw digitules are all fine hairs. Anal ring compound with six hairs. Anal tubercles inconspicuous, setiferous. Mentum dimerous with some hairs at the end. Margin of body bearing a few small conical spines wide apart (sometimes absent), which are in pairs or threes on the abdominal segments; and similar spines are very sparsely scattered on the dorsum where there are also some scattered fine hairs. Epidermis bearing many circular spinnerets of two sizes, those on the dorsal surface being twice as large as those on the ventral.

"Larva dark red, flattish, elliptical, active. Length about one-ninetieth inch. Antennae thick with 6 joints, of which the last is the largest. Feet also rather thick. Tarsus longer than the tibia and digitules are all fine hairs. Anal tubercles normally with moderate setae. Margin of body with only a few very small spines.

"Male unknown."

There is also commonly found on cotton the so-called "black scale," *Saissetia oleae* (Bern.), a species that is widely distributed over the world, with a great variety of host-plants. Here it is not entirely confined to cotton, having been taken as well on sisal, Ceara rubber tree, guava and crotalaria.

It is usually found on the stem or branches of cotton, but never in great numbers, and it is hardly likely to be a serious pest, as its multiplication is checked by both internal parasites and ladybirds.

Remedies: The use of artificial remedies for the control of mealy-bug and scale insects is hardly warranted from a practical standpoint unless in an exceptional outbreak they should threaten the life of the plants. Ordinarily their multiplication will be kept within reasonable bounds by their natural enemies. In case of abnormal increase, the use of a strong nozzle stream of water from a force-pump, to dislodge the egg-sacs, eggs or old shells, followed by spraying with kerosene emulsion (strength 1 to 20), is likely to bring beneficial results.

The introduction of specific parasites for these destructive species, if such exist, is highly desirable.

BOLL-WORM.

Without doubt the worst insect enemy of cotton in Hawaii is the boll-worm, the larva of a Tineid moth, *Gelechia gossypiella* Sdrs. In many parts of the islands its ravages are unknown,

but in the experimental plantings at this Station and elsewhere in and about Honolulu it does great damage to the cotton crop. It is said to have been introduced (unquestionably from India) within comparatively recent years. It has doubtless spread to all the islands, having been reported to this office from Hawaii and Kauai; indeed, that it is not everywhere prevalent can only be accounted for by the small extent to which cotton has been grown.

Gelechia gossypiella is also a major pest of cotton in India. It has been known there for a quarter of a century and is said to have been introduced with Egyptian or American cotton brought in about 1883. Lefroy reports it as now generally present throughout the Indian Ocean region, in India, Ceylon, Burmah, Strait Settlements and German East Africa. The insect is also reported to have been collected in Japan, but Kuwana writes that it is not known there.

Lefroy says of it:

"The pest is apparently universal in India, Ceylon, Burma and the Strait Settlements, causing a very large aggregate loss to cotton in India, which may amount to at least one crore of rupees (over $4,000,000) annually. The destruction of the seed, the staining of the lint, and the loss of young bolls are the principal forms of damage. So far as is known all varieties of cotton now grown as field crops in India are attacked, the American and Egyptian as well as the indigenous. It remains to be seen whether there are any varieties of cotton immune to the pest, but none have definitely proved so up to the present. Unlike the other boll-worms, this species has not been found attacking plants allied to cotton; its wild food-plants appear to be trees with oily seeds which are widely distributed in India."

In Hawaii, according to Perkins, it attacks other plants than cotton. I have bred it from milo (*Thespesia populnea*).

The boll-worm, as its name indicates, attacks primarily the boll, although the immature worms sometimes enter the ovary and devour the young ovules, preventing the normal forming of the boll, which either drops or opens prematurely, before the lint has been formed. In the boll it causes premature opening, rotting and soiling of the lint. The worm also enters the seed, eating its contents. In a planting where no effort was made to control the pest it was estimated that fifty per cent of

the bolls and about fifteen per cent of the seeds were infested. If a field is badly infested, three or four worms may be found

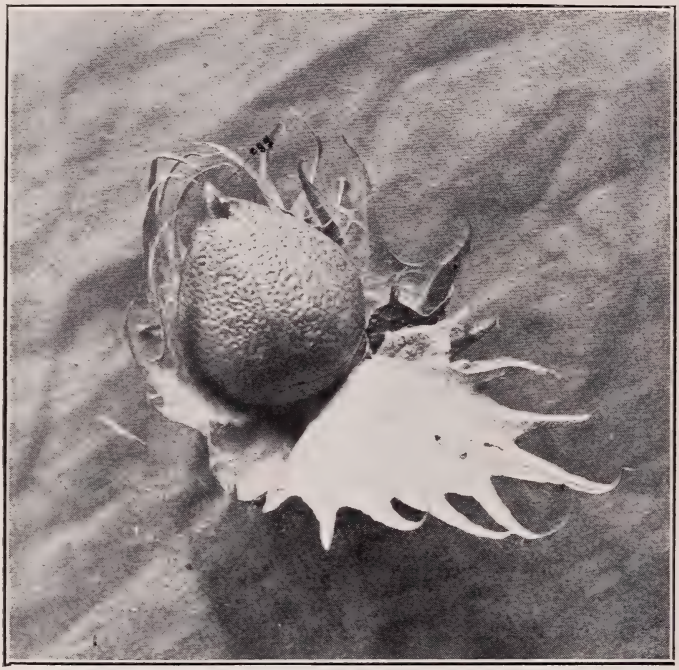

FIG. 9.—Cotton boll showing egg of the bollworm *in situ*. (Photograph by author.)

in one boll, practically destroying the boll as far as its lint is concerned.

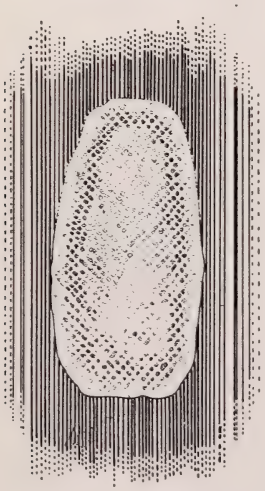

FIG. 10.—Egg of the bollworm, greatly enlarged. (Original)

Life history. There are four distinct stages in the life cycle of the bollworm, as in the case of all butterflies and moths—namely, the egg, larva, pupa, and adult.

The egg. The eggs of the bollworm are deposited singly on the leaves, bracteoles and bolls. They are quite small (about one-fortieth of an inch in longest diameter), flattish and pearly white. They are small enough to be quite inconspicuous and are detected only with the closest scrutiny. The peculiar sculpturing of the egg-surface, which ren-

ders them unmistakable when observed with a hand lens, is shown in Fig. 10. The number of eggs laid by a single moth may be quite large. The eggs turn red before hatching. The egg-stage occupies about ten days.

The larva. The larva is the destructive stage of the insect and the one in which it will be most generally noticed by the cotton-grower. When first hatched the larva is very small and may escape attention. For perhaps a day it moves about over the surface and then it commences to tunnel into the bud or boll. A very small hole with fine pellets of frass about its opening, perhaps the hind portion of the larva protruding, indicates the point of entrance. Within the boll it is hidden from view, but it is feeding and growing all the time, and when the boll bursts open a larva of considerable size will be found inside. At this time the larva has a characteristic appearance which renders it recognizable. It is about half an inch long and an eighth wide, its color a dirty white with four rows of dark-colored spots on the dorsum and one lateral row on each side, the head dark brown and the cervical and supra-anal shields mostly black. Each dark-colored spot on the back represents a protuberance, from which arises a hair, and around each spot is a suffusion of pink—which gives the larva the popular name of pink bollworm. The larval stage occupies about twenty-three days.

Fig. 11a—Bollworm, *Gelechia gossypiella* Sdrs., larva. Nat. size. (Photograph by author.)

Fig. 11b—Bollworm, *Gelechia gossypiella* Sdrs., pupa. Nat. size. (Photograph by author.)

The pupa. The larva usually pupates within the boll, forming a light cocoon in the cotton square near the surface. The chrysalis is brown and three-eighths of an inch in length. It

turns dark just before the moth emerges. The pupal stage occupies about fourteen days.

The adult insect. The perfect insect or imago of the boll-worm is a rather small moth of a gray-brown color with dark blotches and suffusions. The wings expand about three-fourths of an inch. On the front wing there is a large dark area towards the apex. The hind wings are grayish. The fringe on the front wings is brown; it is longer on the hind wings and lighter in color. The moth flies at night and will seldom be seen in daytime. It flies with a swift, darting motion when disturbed. The female begins to lay her eggs in three or four days after leaving the chrysalis, and each individual lays a large number of eggs. The moths live from five to ten days or even longer after emergence.

FIG. 11c—Bollworm, *Gelechia gossypiella* Sdrs., adult moth. Nat. size. (Photograph by author.)

Remedies: The use of artificial remedies to combat the boll-worm is at the present time, for practical reasons, not advised. Relief, it is thought, is to be sought rather in clean culture and the use of certain cultural methods adapted to lessen boll-worm infestation. The regular destruction of infested bolls by burning; severe pruning and burning after the last picking in the fall; the collection and burning of all fallen bolls (clean culture); ginning soon after picking; picking and

FIG. 12—Parasite of the bollworm, *Chelonus blackburni* Cameron. Enlarged ten times. (Copied from Swezey)

burning any badly infested flush out of season;—all these are likely to keep bollworm injury at a minimum.

The boll-worm is to some extent parasitized by hymenopterous flies. The writer has bred *Chelonus blackburni* from it and others are reported. It is also parasitized in India. How effective parasites may be in reducing the ravages of the bollworm is only a matter for conjecture, but the introduction of effective parasites would be highly desirable.

The cotton bollworm of the Southern States, *Heliothis obsoleta,* has not as yet been found to attack cotton here. It often infests corn and has occasionally been bred from other plants. Its parasites are so efficient that it is not expected it will become an important factor in our cotton production.

LEAF-FOLDING CATERPILLAR.

A leaf-folding caterpillar (larva of *Archips postvittanus* Wkr. Tortricidae) affects cotton and does some, although more or less slight, injury to the foliage. The caterpillar is naked and dark green, the shield light colored, slightly brownish. When full-grown the caterpillar measures about an inch in length and is more or less slender. The chrysalis is naked, slender and dark brown. The adult moth has a wing-expanse slightly over one-half inch. The wings are pale brown with darker markings. It is not of sufficient importance to demand especial attention.

FIG. 13—Leaf-feeding caterpillars, a, *Archips postvittanus* Wkr. b, *Cryptoblabes aliena* Swezey, ms. sp., on cotton. (Photograph by author.)

The larva of the Phycitid *Cryptoblabes aliena* has also been found on cotton, but it probably does not feed on the plant, rather on the remains of insects. It is found in mussy places on the leaves and bolls. The full-grown caterpillar is naked,

brown-striped and about three-fourths of an inch long. The chrysalis is slender and brown. The adult moth has a wing expanse of less than half an inch, is pearly gray in color, the fore-wings darker than the hind ones.

An undetermined species of the genus *Myelois* has been

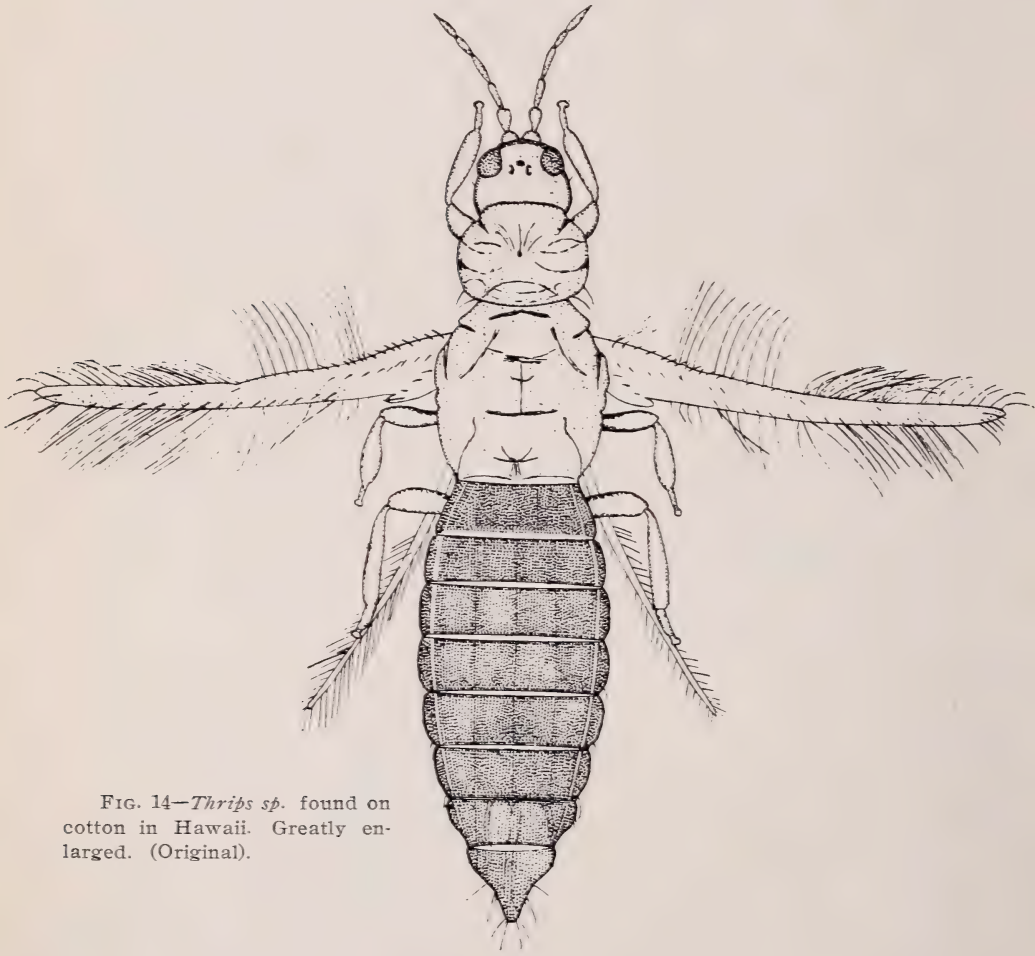

FIG. 14—*Thrips sp.* found on cotton in Hawaii. Greatly enlarged. (Original).

bred from infested cotton bolls. Its larva or caterpillar, about three-fourths of an inch long when full-grown and pale to reddish in color, probably feeds similarly to the Cryptoblabes larva. The moth is small and gray.

STEM BORER.

Insects boring into the stem of the cotton plant have not been observed until recently, although a careful watch has been kept for this class of injury. After a recent wind storm many broken stems and branches in the station planting revealed the work of a small black beetle, *Sinoxylon conigerum* Gerstacker. This beetle attacks dead wood and felled and seasoning timber, having been taken on previous occasions from *Acacia decurrens, Prosopis juliflora* and cotton stumps. It was probably attracted to the standing cotton because of the dry condition of the wood through lack of irrigation. The attacks are almost without exception at the origin of a branching shoot, and as the attacks of two or three beetles are usually concentrated at one point they may do great havoc in a plantation before their work is observed. At the same time it is not believed that they will attack actively growing plants and if this is so their injuries may be entirely avoided by keeping the land in good tilth so as to conserve its moisture.

MINOR PESTS.

Thrips. A species of Thrips is commonly found in the blossoms of cotton but seems to do very little damage. Specimens of the insect were referred to Washington for determination.

FIG. 15—Mite or red spider, *Tetranychus sp.*, found on cotton in Hawaii. (Photograph by author).

Red spider. A species of Tetranychus is also commonly found on the foliage or bolls of cotton. It is probably responsible for some spotting of these parts of the plant but outside of this does little damage, and has never been observed in large numbers. Specimens of this pest were also referred to Washington for determination.

Besides the injurious species already referred to there are three or four insects commonly found on or about cot-

ton without doing any particular damage as far as it is known. A species of Psocidae, determined by Mr. Nathan Banks as *Elipsocus inconstans* Perk., is found with great regularity on cotton, usually about withered leaves or bolls. It probably feeds exclusively on dry, dead vegetable matter and insect remains. Apparently it does no damage to the cotton.

Three coleopterous species, *Epitragus diremptus, Araeocerus fasciculatus* and *Ompatrum serratum,* are also found about cot-

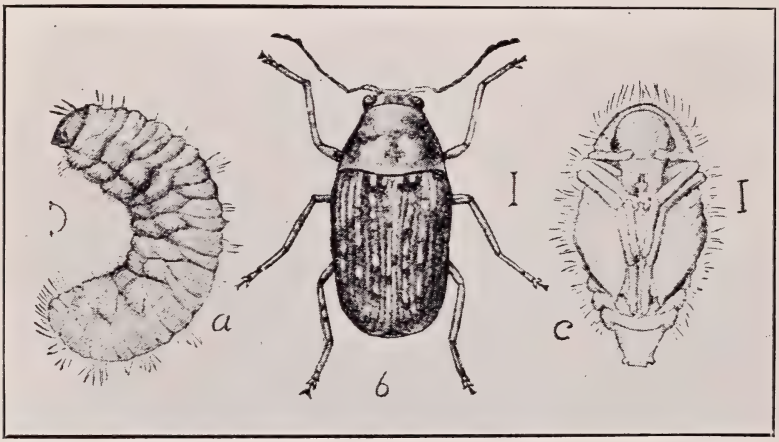

FIG. 16—Coffee been weevil, *Arœocerus fasciculatus: a*, larva; *b*, beetle; *c*, pupa. (Copied from Chittenden).

ton, probably seeking shelter. The last-named species is usually found on the open ground or under trash piles; the two first in crevices in the bolls. Of *Araeocerus fasciculatus* Dr. Howard says:

"*Araeocerus fasciculatus* is a cosmopolitan insect living in the pods of various plants, among others in those of the coffee plant in Brazil, but is never known to attack healthy plants. The perfect weevil is also among the various insects which are mistaken by the planters for the Mexican cotton-boll weevil, but its very short and blunt beak should at once distinguish it from the latter species."

BENEFICIAL INSECTS.

The extraordinary multiplication of insects is counterbalanced in nature by the predatory or parasitic habits of species

of the same class. Just so, the presence of aphids and mealy bugs, which are both largely overproductive, on cotton here, attracts a large number of their natural enemies, many of which were introduced especially to check the ravages of these injurious forms. Among the beneficial species found in the cotton fields may be mentioned the well-known ladybirds or Coccinellid beetles. These differ slightly in their choice of food. *Cryptolaemus montrouzieri* and *Rhizobius ventralis* are known to feed on mealy-bugs; the following feed on aphids: *Coccinella repanda, Platyomus lividigaster, Scymnus notescens, Coccinella abdominalis* and *Scymnus vividus. Orcus chalybeus* feeds on the armored scale insects and *Chilocorus circumdatus* is a general scale insect feeder.

The larvae of Syrphid flies also feed on aphids and a familiar one about cotton is the larva of *Xanthogramma grandicornis* Macq. A much similar, though smaller, larva feeding on the cotton aphid is that of the Agromyzid fly, *Leucopis* sp. Four predaceous Hemiptera, *Zelus renardii, Hyalopeplus pellucidus, Triphleps persequens* (probably feeding on thrips) and *Rhopalus hyalinus,* have also been found on cotton feeding on aphids. These four have actually been taken in the cotton field; there are doubtless many more species that feed in a similar way on aphids.

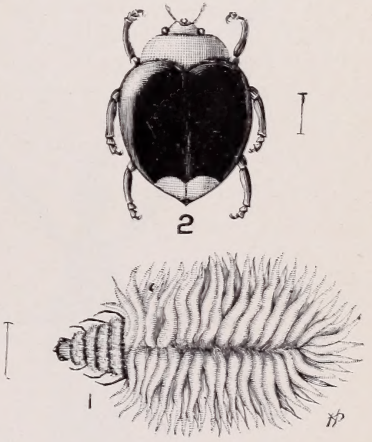

FIG. 17—*Cryptolæmus montrouzieri*, a predaceous species; 1, larva; 2, adult beetle. Nat. size indicated by line (Copied from Kirk.)

GENERAL CONSIDERATIONS.

The present report must be considered as preliminary only. The period of observation has been far too short to speak with much precision about the relative importance of the insects

now affecting cotton. Other pests will in all probability appear, both from among the native insects and from foreign lands. The vast importance of strict quarantine measures with regard to imported seed or other cotton stock is here emphasized.

With respect to the introduced pests of cotton, efforts to secure their natural enemies in the lands from which the pests have come are commendable. Resort to artificial methods, such as the use of insecticides, in combating cotton pests, has not been much advised, for practical reasons, but if their use should become necessary and it were shown that they could be used

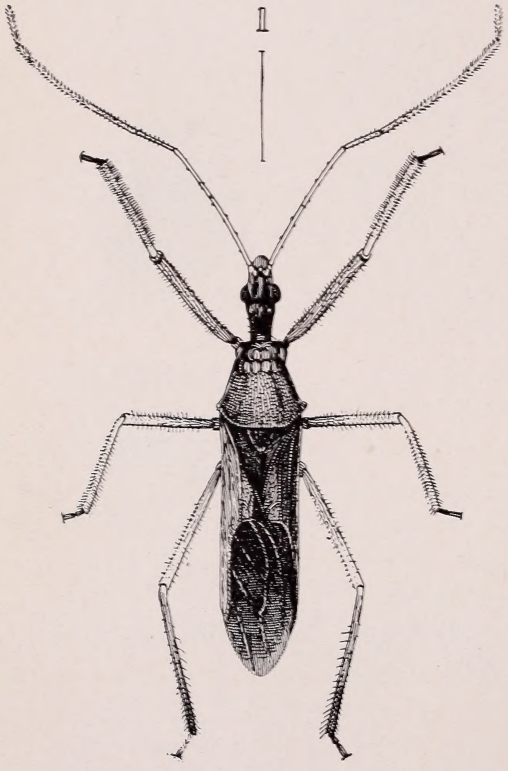

FIG. 18—A predaceous bug, *Zelus renardii* Kolenati. (Copied from Swezey).

effectively, the question of practicality might disappear. In such contingency it is thought desirable to ascertain, as time permits, the relative effectiveness of various insecticides with respect to several of the more important pests.

The most promising field for improvement in conditions undoubtedly lies in cultural methods. In the United States the whole question of boll-weevil control, for instance, has practically resolved itself into the use of certain cultural methods. In all likelihood local problems will ultimately find solution in the utilization of similar devices.

Some stress might be laid on the value of a study of varieties with regard to the different degrees of susceptibility to insect attacks. Little has been done so far in this direction, but it deserves study in the future.